Electronic Supplementary Material (ESI) for Dalton Transactions.

Supporting Information

A study on structural, optical, and electrical characteristics of perovskite $CsPbBr_3$ QDs/2D-$TiSe_2$ nanosheets based nanocomposites for optoelectronic applications

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S1. Characterization Technique

$CsPbBr_3$ NPs and $TiSe_2$ NSs were examined by a transmission electron microscope (TEM) and High Resolution-TEM (HRTEM) of FEI Tecnai G2 F-30 STWIN operating at an accelerating voltage of 300 kV. The X-ray diffraction (XRD) pattern of perovskite NPs and 2D-$TiSe_2$ NSs was recorded using Rigaku mini Flex-600. A trapping mode atomic force microscopic (AFM) was performed by NDMDT-Solve Pro- P47 model system. The Fourier-transform infrared (FTIR) spectroscopic was recorded in transmission mode by Nicolet 5700-IR spectrometer. The field emission scanning electron microscopy (FESEM) studies was performed using Joel, JSM-7610F system. The steady-state fluorescence spectroscopy was recorded by Shimadzu 2401 PC (UV-Visible spectrometer), Fluorolog (Jobin Yvon-Horiba, model-3-11) (Photoluminescence spectrometer), and the lifetime decay was studied using time-correlated single-photon counting in Fluorolog (Jobin Yvon-Horiba, model -3-11) spectrophotometer system.

S2. HRTEM image of QDs and NSs based nanocomposite.

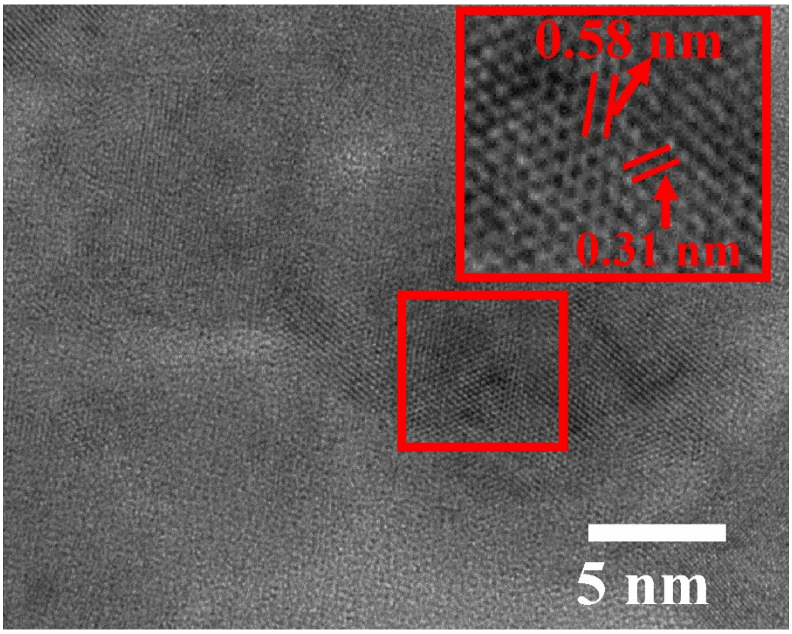

Figure S1: HRTEM image of the nanocomposite (QDs with NSs) structure

S3. Schematic illustration of perovskite QDs and $TiSe_2$ nanosheets

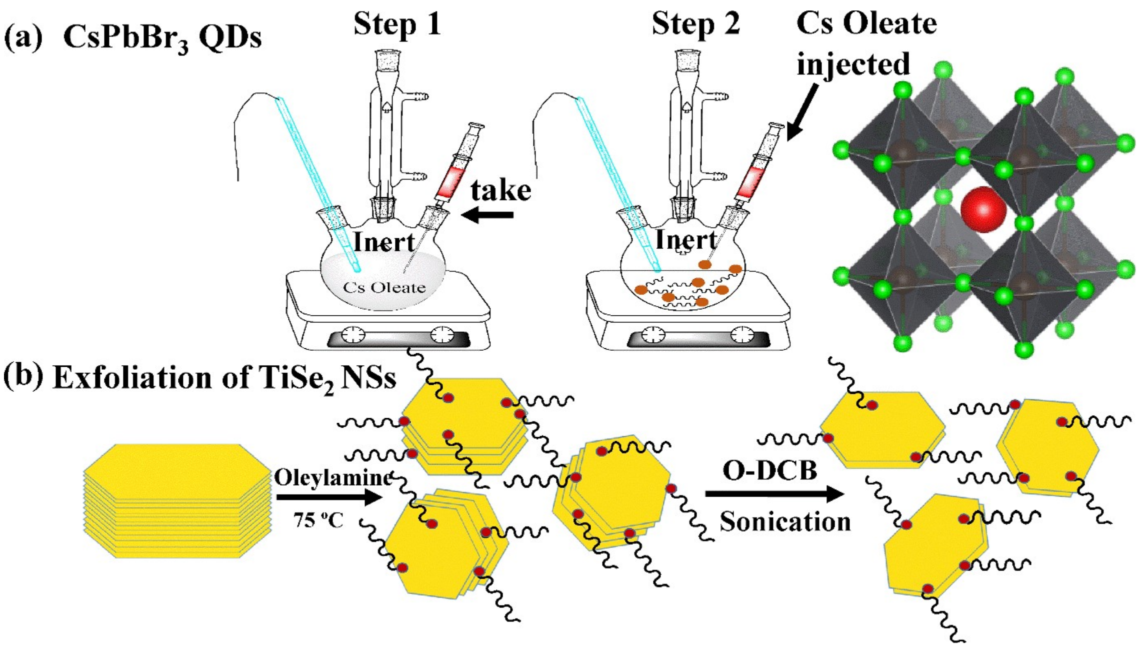

Figure S2: Schematic illustration of (a) synthesis of perovskite $CsPbBr_3$ QDs by hot-injection method and (b) OAm- capped exfoliation of $TiSe_2$ NSs under sonication.

S4. Field Emission Scanning Electron Microscopic (FESEM) micrograph of perovskite QDs and $TiSe_2$ NSs.

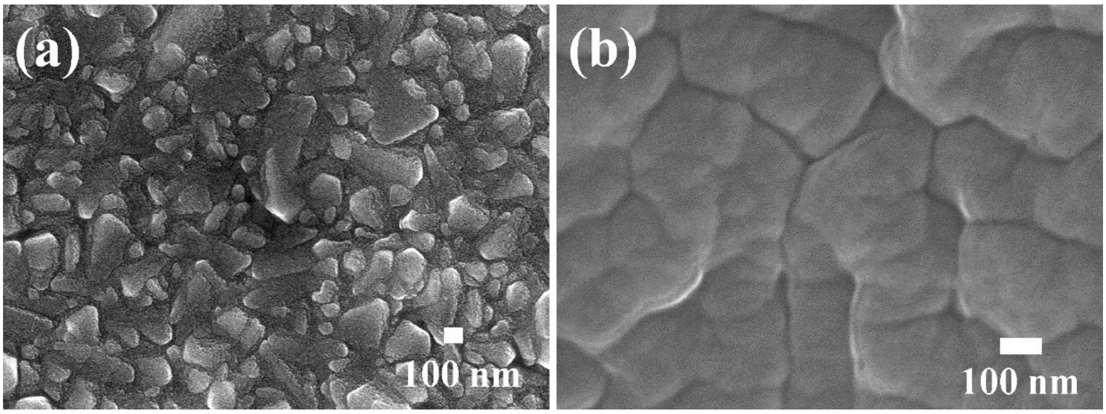

Figure S3. Purified (a) perovskite $CsPbBr_3$ QDs, magnifying view at 40000X, and (b) functionalized (F)-$TiSe_2$ NSs, magnifying view at 90000X.

S5. Atomic force microscopy (AFM)

The AFM micrograph of drop-casted $TiSe_2$ nanosheets on a SiO_2 substrate is shown in figure S4 (a), and the phase-contrast image is shown in Figure S4 (b). AFM studies revealed nanosheets' formation and thickness in the range of 8 to 23 nm (from different spots). It was predicted by its height profile, as shown in Figure S4 (c). The phase-contrast image of $TiSe_2$ NSs confirms the formation of NSs.

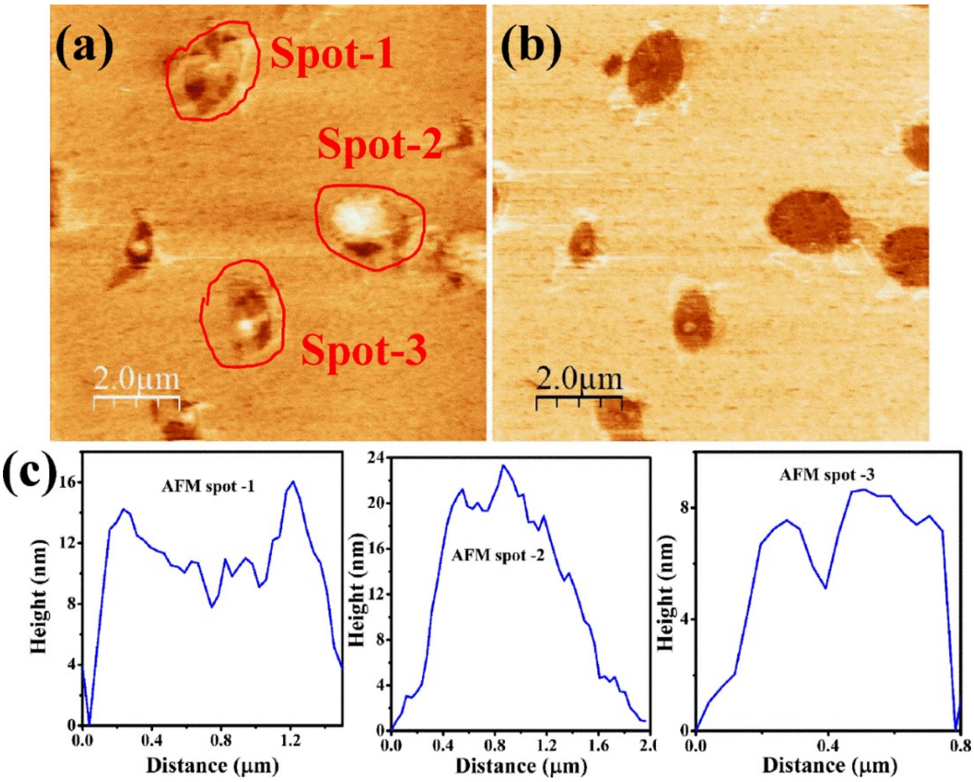

Figure S4. (a) AFM image of functionalized-$TiSe_2$ NSs, (b) phase-contrast image, and (c) height profile of functionalized NSs at different spots.

Table S1. The calculated charge transfer rate constant (K_{ET}) for the nanocomposite.

Nanocomposite	τ_{avg} (ns)	K_{ET} (10^8 s^{-1})
$CsPbBr_3$ + 5 μg/mL $TiSe_2$	4.51	1.5
$CsPbBr_3$ + 10 μg/mL $TiSe_2$	2.73	2.95
$CsPbBr_3$ + 20 μg/mL $TiSe_2$	2.85	2.79

S6. Cyclic voltammetry of $TiSe_2$ NSs.

The cyclic voltammetry analysis was performed to evaluate the valence band maximum (VBM) level of $TiSe_2$ NSs (figure S5). The calculation of VBM of $TiSe_2$ NSs was done by the onset oxidation potential (E_{oxi}) (shown in figure S5).[1, 2]

$$E_{VBM} = (E_{oxi} - E_{1/2}(\text{ferrocence}) + 4.8)\ \text{eV} \quad \textbf{(1)}$$

Where, $E_{1/2}$ (ferrocene) and E_{oxi} value was obtained 0.1 eV and 0.42 eV. The VBM level value is ~ 5.1 eV calculated by using equation (I).

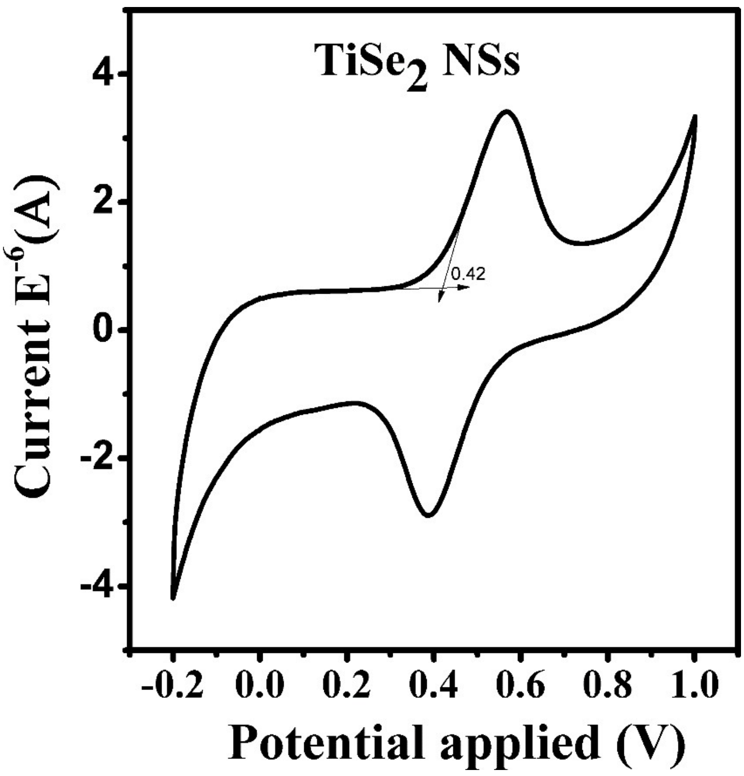

Figure S5. Cyclic voltammogram of $TiSe_2$ NSs**.**

S7. Transient photocurrent (I-t) response of pristine and nanocomposite.

The I-t characteristics of pristine and nanocomposite sample shows good repeatability and stability for many on/off cycles (figure S6). The response time is 1.67s, 1.18s, and 1.19s for pristine, $CsPbBr_3$ + 5 µg/mL $TiSe_2$ and $CsPbBr_3$ + 10 µg/mL $TiSe_2$ sample respectively, and it can be seen that the response time decreases upon change in the concentration of $TiSe_2$ NSs.

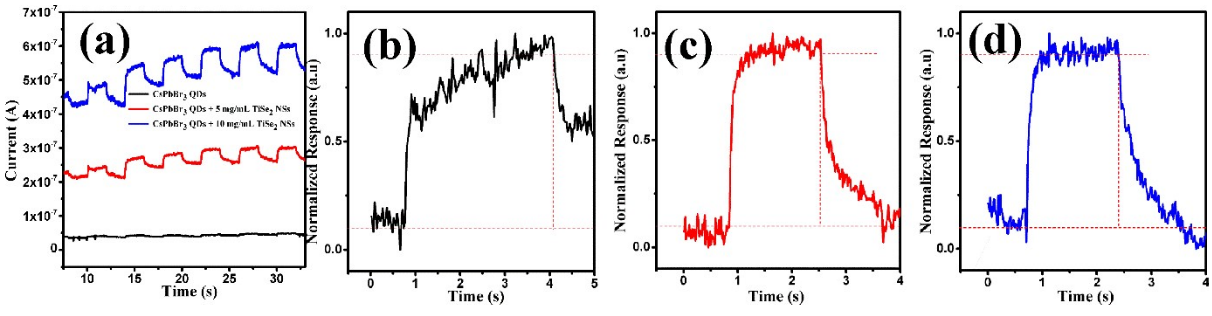

Figure S6. (a) Transient photocurrent of pristine QDs, nanocomposite (QDs with 5 µg/mL $TiSe_2$) and nanocomposite (QDs with 10 µg/mL $TiSe_2$), and (b, c & d) single normalized cycle of the photocurrent of pristine QDs, nanocomposite QDs with 5 µg/mL $TiSe_2$) and nanocomposite (QDs with 10 µg/mL $TiSe_2$),

References

1. Alhalasah, W. and Holze, R., 2007. Electrochemical bandgaps of a series of poly-3-p-phenylthiophenes. Journal of Solid State Electrochemistry, 11(12), pp.1605-1612.
2. Pandey, S., Kumar, A., Karakoti, M., Garg, K.K., Rana, A., Tatrari, G., Bohra, B.S., Yadav, P.K., Singh, R.K. and Sahoo, N.G., 2021. 3D Graphene Nanosheets from Plastic Waste for Highly Efficient HTM free Perovskite Solar Cells. Nanoscale Advances.